

WPS 1043

International Economics Department
The World Bank
November 1992
WPS 1043

Deriving Developing Country Repayment Capacity from the Market Prices of Sovereign Debt

Stijn Claessens
and
George Pennacchi

The market prices of developing countries' debts are imperfect indicators of the countries' payment capacity, for three reasons: the concave shape of the debt's payoff structure, the presence of third-party guarantees, and the differences in the terms of various debt claims. This new model takes those factors into account.

The Policy Research Working Papers disseminate the findings of work in progress and encourage the exchange of ideas among Bank staff and all others interested in development issues. These papers, distributed by the Research Advisory Staff, carry the names of the authors, reflect only their views, and should be used and cited accordingly. The findings, interpretations, and conclusions are the authors' own. They should not be attributed to the World Bank, its Board of Directors, its management, or any of its member countries.

Policy Research
WORKING PAPERS
Debt and International Finance

WPS 1043

This paper — a product of the Debt and International Finance Division, International Economics Department — is part of a larger effort in the department to study the determinants of secondary market prices of developing countries' debt. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Rose Vo, room S8-042, extension 33722 (November 1992, 37 pages).

The market prices of developing countries' debts are imperfect indicators of the countries' payment capacity, for three reasons: the concave shape of the debt's payoff structure, the presence of third-party guarantees, and the differences in the terms of various debt claims.

Claessens and Pennacchi derive an improved indicator of payment capacity by developing a pricing model — using option valuation techniques — that takes these three factors into account.

Applying the model to bonds issued recently by Mexico and Venezuela, they find that the estimated indicator of payment capacity often behaves differently from the raw bond prices themselves, confirming the importance of cleaning the raw prices for these three factors. In

order of importance, the benefits of cleaning raw prices come first from correcting for the effects of different terms (such as fixed versus floating interest rates), followed by the value of third-party enhancements and then by the concavity of the payoff structure.

They find some evidence that the new indicator of repayment capacity conforms better than the raw prices themselves to generally held beliefs about which variables drive a country's repayment capacity. In particular, they find that variables that are often assumed to be related to payment capacity — such as oil prices and the countries' stock market prices — are more closely (and with the right sign) associated with the new estimated measure of payment capacity than are the secondary market prices of the bonds.

The Policy Research Working Paper Series disseminates the findings of work under way in the Bank. An objective of the series is to get these findings out quickly, even if presentations are less than fully polished. The findings, interpretations, and conclusions in these papers do not necessarily represent official Bank policy.

Deriving Developing Country Repayment Capacity from the Market Prices of Sovereign Debt

by

**Stijn Claessens
World Bank**

and

**George Pennacchi
University of Illinois at Urbana-Champaign**

Table of Contents

1.	Introduction	1
2.	The Model	4
2.1	Mexican and Venezuelan Bonds	4
2.2	The Analytical Model	6
2.3	Estimation Techniques	8
3.	The Results	11
3.1	Raw Prices	11
3.2	Estimates of the State Variable Process	12
3.3	The Relationship between State Variables and Economic Variables	14
4.	Conclusions	16
	Appendix A	17
	Appendix B	22
	References	25
	Tables	28
	Figures	33

1. Introduction

In 1985, a secondary market in developing country debt was established. Initially, the market was composed largely of rescheduled commercial bank claims and served as the principal vehicle for transferring ownership between banks and, to a limited extent, other investors. Trading was concentrated in the claims on a few large debtors. In 1989, United States Treasury Secretary Brady proposed official support for debt reduction. Since then the IMF, World Bank, and other official creditors have provided financial support in the form of credit enhancements to five countries (Mexico, Philippines, Costa Rica, Venezuela, and Uruguay) in exchange for debt relief from the commercial creditors of these countries. With the introduction of the Brady plan in 1989, a large share of commercial bank claims have been (or will be) securitized by conversion into bonds, often containing third-party enhancements. This securitization has greatly improved the liquidity and efficiency of the developing country debt market in recent years. Trading volumes have increased from \$1.5 billion in 1985 to about \$200 billion in 1991 and the efficiency of the market has also increased (as measured for instance by bid/ask spreads which have fallen by half or more in the past two years). Mexican Brady-bonds are now one of the most actively traded and most liquid of international bonds.

The secondary market prices of developing country debt have been used as indicators of relative creditworthiness in cross-country and time series analysis. As the market has become more efficient, prices are also increasingly used as benchmarks in the formulation of debt and debt service reduction and/or restructuring packages negotiated by developing countries with their commercial creditors. In general, terms on debt and debt service reduction transactions reflect prices in the secondary market prevailing at the time of the agreement. Because of their use as relative creditworthiness indicators as well as their use in debt negotiations, prices--and the determinants of prices--are of importance to developing countries, the commercial banks and the official creditors (that are financing part of the third-party enhancement).

Many researchers have attempted to explain secondary market debt prices by regressing prices (cross-section, times series or panel data) on a set of explanatory variables such as debt-to-exports ratio, reserves-to-imports ratio, inflation, etc. (e.g., Sachs and Huizinga (1987), Huizinga (1989), Claessens (1990), Cohen (1990), Cohen and Portes (1990), Boehmer and Megginson (1990) and Ozler and Huizinga (1991)). Although this research has provided some valuable insights, it suffers from a number of problems. First, the range of possible repayments on a debt contract implies that an upper limit on the debtor's liability exists (as when no default occurs). As a result, the (present value of) repayments will likely be a concave function of the underlying fundamental factors determining the ability or willingness to pay. Option-based pricing models can derive the secondary market valuation consistent with this (see further Genotte, Kharas and Sadeq (1987), Borensztein and Pennacchi (1990), Cohen (1991), Claessens and Wijnbergen (1990), Chesney and Morisset (1992) and Bartolini and Dixit (1991)). This option-type, non-linear relationship between prices and fundamentals needs to be taken into account when secondary market prices are related to fundamentals.

Second, debt traded in the secondary market is not homogenous across countries or across time. Most research papers make the implicit assumption that the debts of different countries traded on the secondary market are directly comparable and, hence, that available prices can be used in cross-country regressions. But, this assumption is unrealistic: often there will exist a large number of claims on a given country, each with different contractual terms.¹ An obvious difference in terms will be between bonds with fixed and floating interest payments, in which case the relative prices will vary, in part, due to movements in international interest rates.

¹For instance, currently about 20 claims on Brazil and at least five claims on Venezuela are traded, all at different discounts. Across countries, commercial bank obligations will have different maturities, different coupon rates, different indentures, etc. Over time, terms on claims will vary due to reschedulings and restructurings. For instance, restructurings lead to different maturities, grace periods, and/or interest rates.

Accounting explicitly for the terms of the bonds can lead to more efficient estimates of the country's underlying payment capacity (as perceived by the market).

Third, the Brady deals have involved the issuance of a number of new instruments with different forms of enhancements (from third parties and/or through the use of collateral). These enhancements can contribute as much as 20% of the total value of the bonds. Without accounting for these enhancements, cross-section regressions attempting to explain prices of partly collateralized bonds on the ground of country risk factors alone would lead to biased results. The value of the enhancements--such as principal collateralization--is partly a function of international, risk-free interest rates, not only of country risk factors. Preferably, one explicitly values the two components: the value derived from the country's underlying ability and willingness to repay its debt; and the additional value of the third-party enhancements (where the additional value of the enhancements will obviously depend on the stochastic process determining the country's ability and willingness to repay).

In principle, an analysis of a country's repayment capacity would start by modeling the factors that determine its likelihood of repayment. This is complex, however, because one must consider factors that determine both a country's ability as well as its willingness to make debt payments. In the absence of an international bankruptcy court (or the use of "gunboat diplomacy"), the debtor can choose to make payments in order to avoid the imposition of various possible penalties. These penalties can be intertemporal (exclusion of future access to capital markets, see Eaton and Gersovitz (1981)) or intratemporal (trade sanctions, withdrawal of trade credits, see Bulow and Rogoff (1989)). To avoid these penalties from being imposed--which may generate little direct benefits to the creditors--the debtor and the creditors will try to reach an agreement involving some (partial) payment by the debtor. Since the bargaining power of the creditors will depend on the severity of the penalties they can impose, the agreement reached will likely imply that the debtor will pay in relation to the severity of the penalties.

These considerations make it clear that repayments by the country will be driven by a large number of factors, affecting the country's as well as its creditors' position (for example, the general state of the banking system may affect the bargaining power of commercial banks vis-a-vis the debtor country, see Fernandez and Ozler (1991) and Ozler and Huizinga (1991)). A priori it will be difficult to determine the relative importance of each of these factors and to develop an econometric model accordingly. Hence, empirical studies have typically tried to identify variables that best explain repayment capacity by conducting goodness of fit regression tests.

An alternative to this regression fitting approach is to first assume that a developing country's repayment capacity can be summarized by a given stochastic repayment process and then derive a valuation model for particular types of debt claims (e.g., enhanced with third-party guarantees) based on this stochastic process. Using actual secondary market prices of developing country debt, one can then infer the country's underlying stochastic repayment process that is consistent with the previously derived debt valuation model. The derived stochastic process can then be related to the underlying fundamental factors and some hypotheses regarding ability and willingness to pay factors can be tested. In this way one deals in a consistent fashion with: the option-type nature of sovereign debt; the different terms of the various claims (which determine, for instance, the impact of changes in international interest rates on their prices); and the extra value provided by third-party enhancements.

2. The Model

2.1 Mexican and Venezuelan Bonds

We develop such a pricing model for the Mexican and Venezuelan Brady bonds. The Mexican bonds were created in March 1990 by converting approximately \$40 billion of commercial bank claims. They trade in a very liquid and efficient market (bid-ask spreads are around 25 cents, or about 0.4 percent of their price). Two different Mexican Brady bonds exist:

(i) a discount bond, a bond with a principal discounted to equal to 65 percent of its original (pre-rescheduled) face value and having a floating interest rate of LIBOR plus 13/16; and

(ii) a par bond, a bond with a principal equal to its original face value but having a low, fixed interest rate of 6.25 percent.

Both bonds have an original maturity of 30 years. The principal of both bonds is guaranteed through the collateralization of a 30-year, US Treasury zero-coupon bond. The bonds are further credit enhanced by a rolling guarantee that covers a limited value of interest payments and is collateralized by an escrow account.² Specifically, this rolling interest guarantee covers 18 months worth of interest payments (three semi-annual interest payments). The interest earned on the funds in the escrow account accrues every six months to Mexico, provided of course that Mexico pays in full the then due interest repayment. In addition, both bonds include an oil price recapture clause that gives creditors a share in Mexico's oil export revenue if oil prices increase by a certain percentage in the years 1997 and beyond.

The Venezuelan Brady bonds were created in August of 1990 from the conversion of approximately \$19 billion of commercial bank debt. Their terms are very similar to the Mexican bonds: a discount bond (face value equal to 70% of pre-existing bank debt); and a par bond (interest rate of 6.75%).³ Both Venezuelan bonds also have a 30 year maturity, have their principal collateralized, and have an interest guarantee on a rolling basis provided through an escrow account containing 14 months of interest payments. The two Venezuelan bonds have oil recapture rights that are similar to those of the Mexican bonds. The Venezuelan bonds have

²The escrow account is established at the New York Federal Reserve and only securities with at least a AA-rating can be used as collateral.

³In addition, bonds with temporary low interest rates and new money bonds (with no enhancement) were created in the context of the debt conversion. To maintain comparability with Mexico, we did not analyze these bonds.

relatively a higher bid-ask spread than the Mexican bonds, possibly a result of the fact that their outstanding amount is less.

2.2 The Analytical Model

The pricing of the collateralized principal of a Brady bond is straightforward: its value at each point in time will equal the current value of the U.S. Treasury zero-coupon bond expiring on the same maturity date. What is then left to value are the interim interest payments. Valuing the bond's interim interest payments is complicated since they possess default risk but that they are also covered by a limited, rolling guarantee. We characterize the developing country's default risk by a stochastic state variable, z_t , which can be thought of as an index of the country's capacity for repaying its debt. If z_t falls below zero, we assume that the country will default on its interest payments for a limited time equal to τ periods.

The state variable, z_t , is assumed to follow the arithmetic Brownian motion process:

$$(1) \quad dz_t = \mu dt + \sigma dq$$

where dq is a standard Wiener process.

The rolling guarantee is assumed to cover τ periods of interest payments. For analytical simplicity, we assume that if the rolling interest guarantee is called upon, then it is used in full, i.e., in the case of Mexico, it is disbursed over 18 months (three consecutive semi-annual interest payments) and in the case of Venezuela, it is disbursed over 14 months (two and one-third consecutive semi-annual interest payments).⁴ The state variable, z_t , determines when the guarantee is first employed and when the bond issuer subsequently defaults on its promised payments. It is assumed that the guarantee is disbursed over the period T to $T + \tau$ if z_t falls below

⁴This is not as strong an assumption as it may seem: it is likely that once the country defaults on one interest payment, it will default completely on the interest guarantee.

zero for the first time during any time within the interval $T-\tau$ to T . If z_t later takes on a value less than or equal to zero at any time during any future interval $T'-\tau$ to T' , where $T' \geq T + \tau$, then it is assumed that complete default occurs on all promised bond payments over the interval T' to $T'+\tau$.

Our strategy for computing the value of payments for the bond described above is to first value the payments of a bond without the rolling interest guarantee. Second, we then calculate the value of the rolling guarantee alone. By combining these two values, we will obtain the value of payments of a bond that includes the guarantee. A description of this valuation technique is given in Appendix A. There we make the simplifying assumption that bond investors view the country's default risk as diversifiable, a somewhat weaker assumption than risk neutrality.⁵ We then find that if the initial time $t=0$ value of the state variable is $z_0 = z$, then the time 0 probability of the bondholder receiving an interest payment over the interval t_2 to $t_2 + T$ is equal to

$$(2) \quad \begin{aligned} \psi_0(t_2) = & N\left(\frac{z+\mu t_1}{\sigma\sqrt{t_1}}\right) - N_2\left(\frac{-z-\mu t_1}{\sigma\sqrt{t_1}}, \frac{z+\mu t_2}{\sigma\sqrt{t_2}}, -\sqrt{t_1/t_2}\right) \\ & - e^{-2\mu z/\sigma^2} N_2\left(\frac{-z+\mu t_1}{\sigma\sqrt{t_1}}, \frac{z-\mu t_2}{\sigma\sqrt{t_2}}, -\sqrt{t_1/t_2}\right) \end{aligned}$$

where $t_1 = t_2 - \tau$. This implies that the value of the bond's payments over the interval t_2 to $t_2 + \tau$ is equal to their default-free value times the expression $\psi_0(t_2)$. Hence, if we define I_t as a par bond's promised fixed interest payment that comes due at time t , where $t_2 \leq t \leq t_2 + \tau$, then the time 0 value of this interest payment is given by

⁵We allow for interest rate risk premia since our model embeds the Vasicek (1977) model of the term structure of (default-free) interest rates.

$$(3) \quad v_0^{\text{par}}(I_t) = p_0(t) I_t \psi_0(t_2)$$

where $p_0(t)$ is the time 0 price of a default-free zero coupon bond that pays \$1 at time t . Similarly, one can value a discount bond's promised floating rate interest payment to be paid at time t . Let D denote the discount bond's level of principal and let s be the spread over the yield on a default-free six month bond issued six months prior to the interest payment date (e.g., the spread of 13/16% over LIBOR). Then the value of this discount bond interest payment equals⁶

$$(4) \quad v_0^{\text{discount}}(D, t) = [e^{s/2} p_0(t - .5) - p_0(t)] D \psi_0(t_2)$$

These valuation formulas imply that the variability of the prices of the bonds will be less than that of the underlying state variable; for an enhanced bond, both its rolling guarantee as well as its limited liability will lead to the bond's price being a concave function of the state variable. This is illustrated in Figure 1 which plots the theoretical price of Mexico par and discount bonds as a function of the state variable, z .⁷

2.3 Estimation Techniques

Formulas (3) and (4) require default-free, zero-coupon bond prices, $p_0(t)$, maturing at each coupon payment date. We constructed this term structure of bond prices using data on Treasury bill, Treasury strip, and LIBOR rates to estimate the parameters of the Vasicek (1977) bond pricing model. This model then allowed us to find values of $p_0(t)$ for any time until

⁶See Borensztein and Pennacchi (1990) for details in valuing floating rate payments.

⁷These bond prices represent interest rates and times until maturity that existed on March 24, 1990, the beginning of our sample period. A value of $\mu/\sigma = -.222725$ was assumed, which is the value we later obtain using our estimation procedure. The estimates for the state variables z (see below) varied between 1 and 3. Note that the discount bond can be valued above 100 for large values of z because of the spread, s , on the bond.

maturity, t .⁸ Given these default-free bond prices, note that formulas (2), (3), and (4) imply that Brady bond prices are a nonlinear function of the fractions z_t/σ and μ/σ only. Hence, we can normalize $\sigma = 1$, and denote these theoretical bond valuation formulas as $v_t^i(z_t; \mu)$, where $i = 1, \dots, n$ indexes a particular type of bond issued by a given country, such as a discount bond or a par bond.

Now consider the following strategy for estimating the values of μ and the time series of the state variable z_t . Let V_t^i equal the average of the secondary market bid and ask prices of a particular country's type i bond at time t . This average of secondary market quotes corresponds to the theoretical valuation, v_t^i , defined above. Given that we can observe a time series of these secondary market prices for n different types of debt issued by a particular country, we assume that these bid-ask averages measure the country's "true" debt prices with error:

$$(5) \quad V_t = v_t(z_t; \mu) + \varepsilon_t, \quad t = 1, \dots, T$$

where V_t is the n dimensional vector of observed secondary market prices of debt of types i , $i = 1, \dots, n$, observed at time t and v_t is the corresponding n -vector of "true" debt prices; and ε_t is an n -vector of measurement errors. For simplicity, we assume that this vector of

⁸In the Vasicek (1977) model, equilibrium bond prices take the form $p_b(t) = \exp[(1 - e^{-\alpha t})(r_\infty - r) - \frac{1}{2}\sigma_r^2(1 - e^{-\alpha t})^2/(4\alpha^3)]$ where r and r_∞ are the time 0 yields on instantaneous maturity and infinite maturity zero coupon bonds, respectively. α is a measure of the mean reversion of r and σ_r^2 is the instantaneous variance in the change in r over time. α and σ_r were estimated by maximum likelihood following a simplified version of the procedure given in Pennacchi (1991). This involved using a univariate Kalman filter to compute the likelihood function. The data consisted of end of month observations on 30, 90, 180, and 345 day Treasury bills over the period 1968 through 1988 and produced estimates of $\alpha = .095231$ and $\sigma_r = .025339$. Given these parameter values and the above bond price formula, we then solved for the date 0 values of r and r_∞ that were implied by contemporaneous observations on 6 month maturity LIBOR and the price of a Treasury strip that matured nearest to the maturity date of the Brady bond we were evaluating.

measurement noise, ϵ_t , is serially uncorrelated and distributed as $N(0, R)$, where R is an $n \times n$ covariance matrix.

Next, note that equation (1) can be rewritten in discrete time form as

$$(6) \quad z_t = z_{t-\Delta t} + \mu \Delta t + \omega_t$$

where $\omega_t \sim N(0, \Delta t)$. (Recall we normalized $\sigma = 1$.) Hence (5) and (6) are in the form of a generalized state space system. z_t is an unobserved "state" variable and (6) is referred to as the "state-transition equation." V_t is a vector of observed variables and (5) is referred to as the "measurement equation." Now if $v_t(z_t; \mu)$ were linear functions of z_t , then maximum likelihood estimates of μ and the z_t 's could be obtained using a standard, recursive Kalman filter. (For example, see Harvey 1981, Chapter 4.)

However, $v_t(z_t; \mu)$ is a vector of non-linear functions of z_t . Therefore a modification of the Kalman filter that considers functional nonlinearities, called the extended Kalman filter, is needed to obtain (approximate) maximum likelihood estimates of μ and z_t 's (Harvey (1989, p. 160) and Anderson and Moore (1979, p. 195)). The extended Kalman filter uses the same simple recursive computational technique as the standard Kalman filter. However, it does so by linearizing (5) around the conditional mean of z_t using a Taylor series expansion. Further discussion of this technique can be found in Appendix B.

The attraction of this estimation procedure is that it combines a time series of cross-sectional observations in a theoretically consistent and computationally efficient manner. The technique is in the same spirit as Chesney and Morisset (1992) in that it uses information regarding the assumed time series properties of the state variable, z_t , to impose restrictions on the time series of observations. However, the present technique, given the extended Kalman filter's linear approximation, has known statistical properties that allow for hypothesis testing or the computation of confidence intervals. In addition, this technique does not require estimates

of the bonds' instantaneous variances as was needed in previous work such as Borensztein and Pennacchi (1990).

The most important results of our estimation are a point estimate and an asymptotic standard error for μ/σ and a times series of estimates of the z_t 's. These "smoothed" estimates of z_t , $t=1,\dots,T$, make use of the full sample of bond price observations to infer each estimate. This times series of the estimated state variable can then be analyzed in terms of its relationship to other factors affecting the country's debt repayment capacity.

3. The Results

3.1 Raw Prices

We use secondary market prices of the Brady bonds since their introduction (March 24, 1990 for the Mexican bonds and August 4, 1990 for the Venezuelan bonds) until July 1991. Table 1 presents some summary statistics for the raw bond prices for Mexico and Venezuela. As can also be observed from Figure 2, prices of the Mexico par and floating interest discount bonds tend to move together. The two series toward the bottom of Figure 2 give the respective bond prices as a percent of their face values, while the series at the top of Figure 2 give their prices as a percent of their price on the first observation in our sample. The correlation between the rates of return (log differences) on these Mexican Brady bonds is 0.726. While this is certainly high, and up to the end of 1990 bond prices moved together quite closely, it is less than perfect. As can be seen in Figure 3, which plots the time series of Venezuelan Brady bond prices, these bonds move together even less perfectly. The correlation of their rates of return is 0.445. Since a developing country's capacity for repaying its discount and par bonds is driven by the same set of underlying variables, this less than perfect correlation indicates that these prices should not be used as direct measures of this repayment ability. Rather, prices might indeed be viewed as noisy (non-linear) functions of repayment capacity as well as other variables. Figures 2 and 3 indicate that part of their relative price behavior may be explained by interest

rate movements: at the beginning of 1991, the decrease in U.S. dollar interest rates (e.g., LIBOR) contributed to the relatively more rapid rise of the par bond for both Mexico and Venezuela. This points to the value of appropriately modeling the effects of riskfree interest rates.

3.2 Estimates of the State Variable Process

Based on the analytical model of section 2.2, we employed the extended Kalman filter estimation technique outlined in section 2.3. The data consisted of weekly Brady bond prices that were adjusted to account for the additional value of their oil recapture clauses. Using the model of Claessens and van Wijnbergen (1992), oil recapture clause values of 2.11 cents per dollar of old face value for Mexico and 3.14 cents for Venezuela were obtained.⁹ On the basis of the above model, we estimated the parameters of the state variable processes for both Mexico and Venezuela based on a bivariate measurement equation consisting of each country's par and discount bonds. The results are given in Table 2.

The state variable process's drift, μ/σ , is negative both for Mexico and Venezuela (somewhat smaller in magnitude for Venezuela) and measured quite precisely in the case of Mexico. This suggests that in spite of the ex-post rise in the value of the state variable over our sample period, investors were pessimistic about each country's future repayment capacity; they expected the countries' repayment capacities to decline over time.

A measure of how well our theoretical model describes the actual Brady bond prices is given by the coefficients of the measurement error matrix, R . The standard deviations of the measurement "noise" for the par bonds, $\sqrt{r_{11}}$, are very similar but estimated with more precision for Mexico. This might be due, in part, to the longer sample period for Mexico. For both Mexico and Venezuela, the standard deviations of the measurement errors for the discount bonds,

⁹The values of the recapture clause were calculated every week. Since there was very little variation in the value of the recapture clause (standard deviation of .032 cents for Mexico and .023 cents for Venezuela) the average value was used throughout.

the coefficients $\sqrt{r_{22}}$, are smaller than the corresponding par bond measurement errors and are not significantly different from zero. We also see that the point estimates of the correlation coefficients between the par and discount bond measurement errors, ρ_{12} , are negative, but due to their huge standard errors, little can be said regarding this interaction. However, looking at the matrix, R , as a whole, the result that each of the estimated standard deviations are less than \$1.80 (on bonds whose prices ranged between \$40 and \$80) indicates that our model fits the data fairly well.

Table 3 presents statistics on the (smoothed) sample estimates of the fractions z/σ . (To maintain comparability with Table 1, the standard deviations of the log differences of the state variables are calculated here). The volatility of the underlying state variable is much higher, almost by a factor of three, relative to that of the prices (Table 1). This is consistent with the fact that the prices themselves are a concave function of the underlying state variable. Figures 4 (for Mexico) and 5 (for Venezuela) also show that the underlying state variable behaves at times quite different from the prices of the par and discount bond. For Mexico, this is especially evident in early May, 1990, when the state variable experienced a much sharper drop than that of bond prices, and also during the first half of 1991, when the state variable increases more sharply. As for Venezuela, a much sharper improvement of the state variable started during December 1990. Since the effect of the drop in U.S. interest rates on the bond prices is already incorporated, in both cases it represents a genuine improvement in repayment capacity.

Table 4 presents the correlations between the (rates of return on the) bond prices and the (first differences of the) state variable. The results confirm what is apparent from Figures 4 and 5. The correlations between the bond prices and the underlying state variable are significantly different from 1; in case of Venezuela, the par bond price and the state variable have only a correlation of 0.529, confirming the importance of extracting the state variable before modelling ability or willingness to pay.

3.3 The Relationship between State Variables and Economic Variables

To investigate the economic determinants of our estimated state variables for Mexico and Venezuela, we regressed them on a number of economic variables. Given the weekly frequency of the bond price data which produced our state variable estimates, we choose economic variables that could also be obtained at a weekly frequency: oil prices, the performance of the domestic stock market (the value of the Mexico country fund as traded in New York and an index of the Venezuela stock market in dollars) and two series of Mexican domestic interest rates (one denominated in dollars, the other in pesos). Oil prices can be expected to influence Mexico's and Venezuela's ability to repay. Domestic stock prices will reflect domestic market expectations of future corporate profit growth and in that respect be an indicator of ability to repay. The value of the Mexico country fund in New York will not only reflect expectations about Mexico's future corporate growth but also be an indication of investors' perceptions about their ability to repatriate their earnings and capital (as reflected in the discount of the fund's price from its net asset value). Domestic interest rates will indicate the restrictiveness of Mexican monetary policy, which will reflect Mexico's general access to fresh foreign funds and its ability to repay.¹⁰

Table 5 presents the results of (typical) regressions of the bond prices and the underlying state variables on the various economic variables. The first column gives the dependent variable that is used in a particular regression. The Table documents that both bond prices and state variables are only weakly related to the economic variables. Except for some regression intercepts, no one parameter estimate is significantly different from zero. What is encouraging, however, is that for both Mexico and Venezuela, the regressions of the state variable on economic variables result in an improvement in overall fit (R^2 as well as the p-values for the F-statistics) compared to the bond price regressions. In addition, the signs of the parameter

¹⁰Oks (1990) finds that the Mexican domestic interest rate reflects, in addition to international interest rates and expectations of exchange rate movements, the fiscal situation of the government. In particular, he finds that the difference between domestic bonds that fall due and Mexico's foreign exchange reserves is an important explanatory variable.

estimates using the state variable as dependent variable are more in line with predictions from theoretical models on the ability and willingness of sovereign countries to pay. For example, in the case of Mexico the parameter estimate for the Mexico country fund using the state variable is positive while it is negative for the raw bond prices. This result is robust to the inclusion of other independent variables as can be seen from the comparing the first and the last sections of Table 5. Similar results obtain when examining the regression coefficients on the oil price change for both Mexico and Venezuela. For the state variable regressions, this coefficient is positive and large, while the corresponding coefficient for the raw bond price regressions is either small or negative. Nevertheless, the fit of the regressions remains in general poor. Other variables, such as gross reserves, monetary base, and the amount of domestic debt that matured in a given month, were also used as independent variables. However, these had even less explanatory power, largely because these variables are only available at a monthly frequency.

A more formal test was undertaken to check whether the parameter estimates in the regressions are significantly different from each other. Table 6 provides the F-statistics and p-values for pair-wise comparisons of equality of parameter estimates. For Venezuela there is some evidence that the parameter estimates reported in Table 5 are significantly different between using the state variable and the bond prices as dependent variables. Table 6 also reports the result for the regression for Mexico with only two independent variables (country fund and Pagafes); in this case parameter estimates are also more likely to be different (p-values of 9 and 12 percent). Our results taken together, there appears to be evidence that deriving a state variable process from secondary market bond prices leads to a better indicator of a country's underlying payment capacity.

4. Conclusions

This paper has shown that accounting for the effects of concavity in a developing country bond's payoff structure, as well as various bond contract features (including third-party guarantees), leads to an improved indicator of the country's repayment capacity. Applying the model to bonds recently issued by Mexico and Venezuela, we find that the estimated repayment capacity behaves, at times, quite differently from the secondary market bond prices themselves. We can attribute some of the variation in payment capacity to exogenous economic factors. Thus, the differences we find between secondary market bond prices and our derived measure of repayment capacity provides suggestive evidence that investigations into the determinants of repayment capacity that employ only secondary market bond prices may be biased.

Appendix A

This appendix computes the probability of default for a bond which contains a rolling, partial guarantee of interest payments. The guarantee is assumed to cover τ periods of interest payments and is assumed to be used, in full, once the bond issuer first fails to make an interest payment. The state variable, $z(t)$, determines when the guarantee is first employed and when the bond issuer subsequently defaults on its promised payments. It is assumed that the guarantee is used over the period T to $T + \tau$ if $z(t)$ falls below zero for the first time during any time within the interval $T - \tau$ to T . If $z(t)$ later takes on a value less than or equal to zero at any time during any future interval $t' - \tau$ to t' , where $t' \geq T + \tau$, then it is assumed that complete default occurs on all promised bond payments over the interval t' to $t' + \tau$.

To derive the risk-neutral value of payments for the bond described above, we first value the payments of a bond without a guarantee. Second, we calculate the value of the guarantee, alone. By combining these two values, we will then obtain the value of payments of a bond that includes the guarantee.

Valuing the payments for a bond that carries no third-party guarantee requires that we first compute the probability that $z(t)$ is less than zero at any time during the interval t_1 to t_2 where $t_1 = t_2 - \tau$. This measurement represents the probability of default on interest payments over the interval t_2 to $t_2 + \tau$ for this bond. To simplify the following notation, denote z_t as the value of the state variable, $z(t)$, at time t . Let the current time be $t_0 = 0$, and assume $z_0 = z > 0$. Recall that the state variable, $z(t)$, is assumed to be an arithmetic Brownian motion process with drift μ and standard deviation σ . Denote $0(t_1, t_2)$ as the event that $z(t)$ takes the value of zero (or passes through zero) at least once during the interval t_1 to t_2 . One can also think of this event as $z(t)$ being "absorbed" at the origin, where zero is an absorbing barrier. Then

$$\begin{aligned}
& (P\{\min(z(t)) < 0, t \in (t_1, t_2)\} = P\{z_1 < 0\} + P\{z_1 > 0\}P\{0(t_1, t_2) | z_1 > 0\}) \\
& (A.1) \quad = N\left(\frac{-z - \mu t_1}{\sigma \sqrt{t_1}}\right) + \int_0^\infty P\{0(t_1, t_2) | z_1\} f(z_1 | z(0) = z) dz_1
\end{aligned}$$

where $N(\bullet)$ denotes the standard normal distribution function and f is the conditional density function of $z(t)$, given by

$$(A.2) \quad f(z_1 | z(0) = z) = \frac{1}{\sigma \sqrt{t_1}} n\left(\frac{z_1 - z - \mu t_1}{\sigma \sqrt{t_1}}\right)$$

where $n(\nu)$ is the standard normal density function.

$P\{0(t_1, t_2) | z_1\}$ is the probability of $z(t)$ being "absorbed" at the zero boundary over the interval (t_1, t_2) , given it equals $z_1 > 0$ at time t_1 . This distribution is given by Ingersoll (1987) p. 353 equation (34b).

$$(A.3) \quad P\{0(t_1, t_2) | z_1\} = N\left(\frac{-z_1 - \mu \tau}{\sigma \sqrt{\tau}}\right) + e^{-2\mu z_1 / \sigma^2} N\left(\frac{-z_1 + \mu \tau}{\sigma \sqrt{\tau}}\right)$$

Substituting (A.2) and (A.3) into (A.1), we have

$$\begin{aligned}
& P\{\min(z(t)) < 0, t \in (t_1, t_2)\} = N\left(\frac{-z - \mu t_1}{\sigma \sqrt{t_1}}\right) + \\
& (A.4) \quad \int_0^\infty \left[N\left(\frac{-z_1 - \mu \tau}{\sigma \sqrt{\tau}}\right) + e^{-2\mu z_1 / \sigma^2} N\left(\frac{-z_1 + \mu \tau}{\sigma \sqrt{\tau}}\right) \right] \frac{1}{\sigma \sqrt{t_1}} n\left(\frac{z_1 - z - \mu t_1}{\sigma \sqrt{t_1}}\right) dz_1
\end{aligned}$$

The above integral can be simplified (e.g., see Geske (1979) p. 80) to obtain

$$\begin{aligned}
& P\{\min(z(t)) < 0, t \in (t_1, t_2)\} = \\
(A.5) \quad & N\left(\frac{-z - \mu t_1}{\sigma \sqrt{t_1}}\right) + N_2\left(\frac{z + \mu t_1}{\sigma \sqrt{t_1}}, \frac{-z - \mu t_2}{\sigma \sqrt{t_2}}, -\sqrt{t_1/t_2}\right) \\
& + e^{-2\mu z/\sigma^2} N_2\left(\frac{z - \mu t_1}{\sigma \sqrt{t_1}}, \frac{-z + \mu t_2}{\sigma \sqrt{t_2}}, -\sqrt{t_1/t_2}\right)
\end{aligned}$$

where $N_2(x, y, \rho)$ is the standard normal bivariate distribution function for random variables x and y having correlation coefficient, ρ . Hence, (A.5) gives the probability that a bond without a guarantee will default, making no payment, during the time interval t_2 to $t_2 + \tau$. One minus this probability times the value of the (default-free) promised payment on the bond over the interval t_2 to $t_2 + \tau$ then gives us the value of the payments on a bond that carries no third-party guarantee.

Our second step is to compute the value of the third-party, rolling guarantee. The risk-neutral of the guarantee applied to bond payments over the interval from t_2 to $t_2 + \tau$ is equal to the promised bond payments over this interval times the probability of the guarantee being exercised. This probability of exercise is the probability that $z(t)$ first equals zero during the interval $t_1 = t_2 - \tau$ to t_2 , i.e., the probability that $z(t)$ is "absorbed" at the zero boundary between t_1 and t_2 . This probability can also be thought of as being equal to the difference in the first passage (below the zero boundary) probabilities of $z(t)$ at t_2 and t_1 . The probability of $z(t)$ being "absorbed" at the zero boundary from time 0 to time t_2 is

$$(A.6) \quad P\{0(0, t_2) | z\} = N\left(\frac{-z - \mu t_2}{\sigma \sqrt{t_2}}\right) + e^{-2\mu z/\sigma^2} N\left(\frac{-z + \mu t_2}{\sigma \sqrt{t_2}}\right)$$

while the lower probability of $z(t)$ being absorbed at the zero boundary from 0 to time t_1 is

$$(A.7) \quad P\{0(0,t_1)|z\} = N\left(\frac{-z-\mu t_1}{\sigma\sqrt{t_1}}\right) + e^{-2\mu z/\sigma^2} N\left(\frac{-1+\mu t_1}{\sigma\sqrt{t_1}}\right)$$

The difference between (A.6) and (A.7) is the probability of the guarantee being exercised beginning at date t_2 . Hence, this probability times the value of the promised payments on the bond over the interval t_2 to $t_2 + \tau$ is the value of the guarantee for this time period.

Using (A.5), (A.6), and (A.7), we see that the risk-neutral value of the bond's payments over the interval t_2 to $t_2 + \tau$ is equal to their default-free value times the expression

$$(A.8) \quad \begin{aligned} & \left[1 - N\left(\frac{-z-\mu t_1}{\sigma\sqrt{t_1}}\right) - N_2\left(\frac{z+\mu t_1}{\sigma\sqrt{t_1}}, \frac{-z-\mu t_2}{\sigma\sqrt{t_2}}, -\sqrt{t_1}/\sqrt{t_2}\right) \right. \\ & \quad \left. - e^{-2\mu z/\sigma^2} N_2\left(\frac{z-\mu t_1}{\sigma\sqrt{t_1}}, \frac{-z+\mu t_2}{\sigma\sqrt{t_2}}, -\sqrt{t_1}/\sqrt{t_2}\right) \right] + \\ & N\left(\frac{-z-\mu t_2}{\sigma\sqrt{t_2}}\right) - N\left(\frac{-z-\mu t_1}{\sigma\sqrt{t_1}}\right) + e^{-2\mu z/\sigma^2} \left[N\left(\frac{-z+\mu t_2}{\sigma\sqrt{t_2}}\right) - N\left(\frac{-z+\mu t_1}{\sigma\sqrt{t_1}}\right) \right] \\ & = N\left(\frac{z+\mu t_1}{\sigma\sqrt{t_1}}\right) + N\left(\frac{-z-\mu t_2}{\sigma\sqrt{t_2}}\right) - N\left(\frac{-z-\mu t_1}{\sigma\sqrt{t_1}}\right) - N_2\left(\frac{z+\mu t_1}{\sigma\sqrt{t_1}}, \frac{-z-\mu t_2}{\sigma\sqrt{t_2}}, -\sqrt{t_1}/\sqrt{t_2}\right) \\ & \quad + e^{-2\mu z/\sigma^2} \left[-N_2\left(\frac{z-\mu t_1}{\sigma\sqrt{t_1}}, \frac{-z+\mu t_2}{\sigma\sqrt{t_2}}, -\sqrt{t_1}/\sqrt{t_2}\right) + N\left(\frac{-z+\mu t_2}{\sigma\sqrt{t_2}}\right) - N\left(\frac{-z+\mu t_1}{\sigma\sqrt{t_1}}\right) \right] \end{aligned}$$

Based on properties of the univariate and bivariate normal distributions (see Zelen and Severo (1972) p. 936), the above expression simplifies to

$$\begin{aligned}
&= N\left(\frac{z+\mu t_1}{\sigma\sqrt{t_1}}\right) - N_2\left(\frac{-z-\mu t_1}{\sigma\sqrt{t_1}}, \frac{z+\mu t_2}{\sigma\sqrt{t_2}}, -\sqrt{t_1}/\sqrt{t_2}\right) \\
&- e^{-2\mu z/\sigma^2} N_2\left(\frac{-z+\mu t_1}{\sigma\sqrt{t_1}}, \frac{z-\mu t_2}{\sigma\sqrt{t_2}}, -\sqrt{t_1}/\sqrt{t_2}\right)
\end{aligned}
\tag{A.9}$$

Hence, (A.9) is the probability of the bondholder receiving the bond's promised payments during the interval t_2 to $t_2 + \tau$.

Appendix B

This appendix describes the extended Kalman Filter technique that is used to obtain (approximate) maximum likelihood estimates of the state variables, z_t , and their expected change per unit time, μ .

Recall that equation (5) in the text describes the measurement equation of our state space system where V_t is the n dimensional vector of observed secondary market prices of debt of types i , $i = 1, \dots, n$, observed at time t and v_t is the corresponding n -vector of "true" debt prices. ε_t is an n -vector of measurement errors which is assumed to be serially uncorrelated and distributed as $N(0, R)$. Equation (3) in the text gives the corresponding state transition equation.

The extended Kalman filter uses the same simple recursive computational technique as the standard Kalman filter, but linearizes the system's measurement equation around the time $t-\Delta t$ conditional mean of z_t , denoted $\hat{z}_{t|t-\Delta t}$, using a Taylor series expansion:

$$(B.1) \quad v_t^i(z_t) = v_t^i(\hat{z}_{t|t-\Delta t}) + (z_t - \hat{z}_{t|t-\Delta t}) \left. \frac{\partial v_t^i(z_t)}{\partial z_t} \right|_{z_t = \hat{z}_{t|t-\Delta t}}$$

This estimation technique is now briefly described below.

Define η_t as an n -dimensional vector of prediction errors or "innovations" in V_t .

$$(B.2) \quad \eta_t = V_t - \hat{V}_t = V_t - v_t(\hat{z}_{t|t-\Delta t})$$

where

$$(B.3) \quad \hat{z}_{t|t-\Delta t} = \mu \Delta t + \hat{z}_{t-\Delta t|t-\Delta t} = \mu \Delta t + E_{t-\Delta t} [z_{t-\Delta t} | V_{t-\Delta t}, V_{t-2\Delta t}, \dots, V_0]$$

is the predicted level of z_t given information at time $t-\Delta t$. Define G_t as the variance of z_t given observations on V_t up until time t , i.e.,

$$(B.4) \quad G_t = E_t[(z_t - \hat{z}_t)^2]$$

and define H_t as the $n \times n$ covariance matrix of η_t . Then the recursive equations of the Extended Kalman filter can be written as

$$(B.5) \quad \hat{G}_t = G_{t-\Delta t} + \Delta t$$

$$(B.6) \quad H_t = \bar{v}_t \hat{G}_t \bar{v}_t' + R$$

$$(B.7) \quad \hat{z}_t = \mu \Delta t + \hat{z}_{t-\Delta t} + \hat{G}_t \bar{v}_t H_t^{-1} \eta_t$$

$$(B.8) \quad G_t = \hat{G}_t - \hat{G}_t \bar{v}_t' H_t^{-1} \bar{v}_t \hat{G}_t$$

where \bar{v}_t is an $n \times 1$ vector whose i th element, \bar{v}_t^i , equals

$$(B.9) \quad \bar{v}_t^i = \left. \frac{\partial v_t^i(z)}{\partial z_t} \right|_{z_t = \hat{z}_{t-1}}$$

Note that we can also compute the formula for the derivative $\partial v_t^i / \partial z_t$, so computing this Taylor approximation is fairly straightforward. Using this linearization, the recursive estimation technique proceeds in the same manner as the standard Kalman filter.

Given starting estimates of z_0 and G_0 , equations (B.2), (B.5), (B.6), (B.7), and (B.8) allow us to recursively compute the sequence of innovations, η_t , and their covariance matrices, H_t . The log-likelihood function for these innovations is

$$(B.10) \quad L = \sum_t L_t = \sum_t -\frac{1}{2}(\log |H_t| + \eta_t H_t^{-1} \eta_t)$$

Using a numerical iteration technique, the parameters μ and R that maximize (B.10) can be found. Given these parameters, we can then compute "smoothed" estimates of time series for z_t . Smoothed estimates of the z_t 's are optimal estimates based on the full sample of observations, V_T , not just those preceding time t . (See Anderson and Moore (1979) or Harvey (1981) for a discussion of this technique.)

References

- Anderson, Brian D. O., and John B. Moore (1979), Optimal Filtering, Prentice-Hall, Inc., Englewood Cliffs, NJ.
- Bartolini, Leonardo, and Avinash Dixit (1991), "Market Valuation of Illiquid Debt and Implications for Conflicts Among Creditors," IMF Staff Papers, 38.
- Boehmer, Ekkehart, and William Megginson (1990), "Determinants of Secondary Market Prices for Developing Country Syndicated Loans," Journal of Finance 45(5), December 1990.
- Borensztein, Eduardo, and George Pennacchi (1990), "Valuation of Interest Payment Guarantees on Developing Country Debt," IMF Staff Papers 37, 806-824.
- Bulow, Jeremy, and Kenneth Rogoff (1989), "A Constant Recontracting Model of Sovereign Debt," Journal of Political Economy, 97 (February): 155 - 178.
- Chesney, Marc, and Jacques Morisset (1992), "LDCs' Creditworthiness and the Secondary Market of the Price of Debt: a Theoretical Approach and an Empirical Analysis," PRE Working Paper No. 916, World Bank.
- Claessens, Stijn, (1990), "The Debt Laffer-Curve: Some Estimates," World Development, Vol. 18, No 12, pp. 1671-1677.
- Claessens, Stijn, and Sweder van Wijnbergen (1990), "An Option-Pricing Approach to Secondary Market Debt," PRE Working Paper 333, World Bank.
- (1991), "The 1990 Mexico and Venezuela Recapture Clauses: An Application of Average Price Options," forthcoming, Journal of Banking and Finance
- Cohen, Daniel (1990), "Debt Relief: Implications of Secondary Market Discount and Debt Overhangs," World Bank Economic Review, 4 (1):43-53
- Cohen, Daniel (1991), "A Valuation Formula for LDC Debt," PRE Working Paper No. 763, World Bank, September.

- Cohen, Daniel, and Richard Portes (1990), "The Price of LDC Debt," CEPREMAP, mimeo, June 1990.
- Eaton, Jonathan, and Mark Gersovitz (1981), "Debt with Potential Repudiation: Theoretical and Empirical Analysis," Review of Economic Studies, 48, 289-309.
- Fernandez, Raquel, and Sule Ozler (1991), "Debt Concentration and Secondary Market Prices," PRE Working Paper No. 570, The World Bank.
- Gennotte, Gerard, Homi Kharas and Sayeed Sadeq (1987), "A Valuation Model for Developing-Country Debt with Endogenous Rescheduling," World Bank Economic Review, Vol 1, Nr 2
- Geske, Robert (1979), "The Valuation of Compound Options," Journal of Financial Economics 7, pp. 63-81.
- Harvey, Andrew C. (1981), Time Series Models, Halsted Press, a division of John Wiley & Sons, New York.
- Harvey, Andrew C. (1989), Forecasting. Structural Time Series Models and the Kalman Filter, Cambridge University Press, Cambridge.
- Huizinga, Harry (1989), "The Commercial Bank Claims on Developing Countries: How Have Banks been Affected," in Ishrat Husain and Ishac Diwan, eds, Dealing with the Debt Crisis, The World Bank.
- Ingersoll, Jonathan E. (1987), Theory of Financial Decision Making, Rowman & Littlefield Publishers, Totowa, NJ.
- Oks, Daniel (1991), "Devaluations Expectations and Interest Rates in Mexico; the Role of Domestic Management," Internal Discussion Paper 98, The World Bank, May.
- Ozler, Sule, and Harry Huizinga (1991), "How Factors in Creditor Countries Affect Secondary Market Prices for Developing Country Debt," PRE Working Paper No. 622, World Bank, March.

- Pennacchi, George G. (1991), "Identifying the Dynamics of Real Interest Rates and Inflation: Evidence Using Survey Data," Review of Financial Studies 4, 53-86.
- Sachs, Jeffrey, and Harry Huizinga (1987), "U.S. Commercial Banks and the Developing-Country Debt Crisis," Brookings Papers on Economic Activity, Nr. 2, 1987.
- Vasicek, Oldrich A. (1977), "An Equilibrium Characterization of the Term Structure," Journal of Financial Economics 5, 177-88.
- Zelen, Marvin, and Norman C. Severo (1972), "Probability Functions," in Milton Abramowitz and Irene A. Stegun, eds., Handbook of Mathematical Functions, Dover Publications, New York.

Table 1: Summary Statistics (Weekly Log Differences)			
Mexico	<u>Mean</u>	<u>Standard Deviation</u>	<u>Number of Observations</u>
Par	0.005025	0.026026	62
Discount	0.003643	0.017839	62
Venezuela			
Par	0.006832	0.018472	43
Discount	0.004181	0.015318	43

Note: Data obtained from Salomon Brothers.

Table 2: State Variable Process Estimates: Mexico and Venezuela

Mexico				
	Variable	SD	T	Sig.
Drift	-0.2227	0.0325	6.85	*
$\sqrt{r_{11}}$	1.7945	0.1741	10.31	*
$\sqrt{r_{22}}$	0.0000	0.3871	0.00	
ρ_{12}	-0.2487		0.00	
Ln likelihood:	-2.06212	130.4005		
Venezuela				
	Variable	SD	T	Sig.
Drift	-0.1467	0.1267	1.16	
$\sqrt{r_{11}}$	1.5757	0.7346	2.14	*
$\sqrt{r_{22}}$	0.7296	0.7378	0.99	
ρ_{12}	-0.9999	11.9286	0.08	
Ln likelihood:	-2.19131			

Table 3: Statistics on the Sample Estimates of z/σ (Log Differences)		
	Mean	Standard Deviation
Mexico	0.012325	0.070417
Venezuela	0.016894	0.056970

Table 4: Correlations between Underlying State Variables and Economic Variables (Log first differences for bond prices, first differences for the state variable)		
Mexico	Discount	State
Par	0.72607	0.63234
Discount		0.84453
Venezuela	Discount	State
Par	0.44497	0.52940
Discount		0.71312

Table 5: Regressions of State Economic Variables and Bond Prices on Variables

(State variables as first differences
bond prices as log first differences)

Mexico	Intercept	Fund	WTI	CETES	PAGAF ES	R ²	F-stat (p-value)
State	0.396 (1.751)	0.276 (1.058)	0.050 (0.256)	6.004 (0.854)	0.036 (1.441)	0.073	1.117 (0.36)
Par	0.035 (1.751)	-0.055 (0.960)	0.030 (0.698)	0.0005 (0.426)	-0.003 (0.560)	0.023	0.331 (0.87)
Discount	0.055 (1.625)	-0.032 (0.826)	-0.014 (0.469)	0.0006 (0.842)	-0.005 (1.343)	0.049	0.733 (0.57)
Venezuela							
State	0.033 (2.013)	---	0.226 (1.236)	---	---	0.036	1.528 (0.22)
Par	0.007 (2.312)	---	-0.020 (0.634)	---	---	0.010	0.397 (0.53)
Discount	0.039 (1.675)	---	0.015 (0.568)	---	---	0.008	0.330 (0.57)
Mexico							
State	0.260 (1.720)	0.240 (0.987)	---	---	-0.017 (1.55)	0.059	1.843 (0.17)
Par	0.017 (0.511)	-0.043 (0.807)	---	---	-0.0009 (0.340)	0.012	0.365 (0.70)
Discount	0.033 (1.463)	-0.028 (0.772)	---	---	-0.0022 (1.298)	0.035	1.061 (0.35)

Note: t-statistics in parenthesis.

Fund is the weekly rate of return on the Mexico Fund.

WTI is the West Texas Intermediate oil price.

CETES is interest rate on peso-denominated, 28-days Mexican government debt.

Pagafes is the interest rate on a dollar indexed, 28-days Mexican government debt.

Table 6: Test of Identical Coefficients

Mexico	F	p value
State - Par	1.53	0.21
State - Discount	1.30	0.28
Venezuela		
State - Par	2.18	0.15
State - Discount	1.63	0.21
Mexico		
State - Par	2.55	0.09
State - Discount	2.19	0.12

**Note: F -statistic
values and probability > F.**

Figure 1

MEXICAN PAR & DISCOUNT BOND PRICES

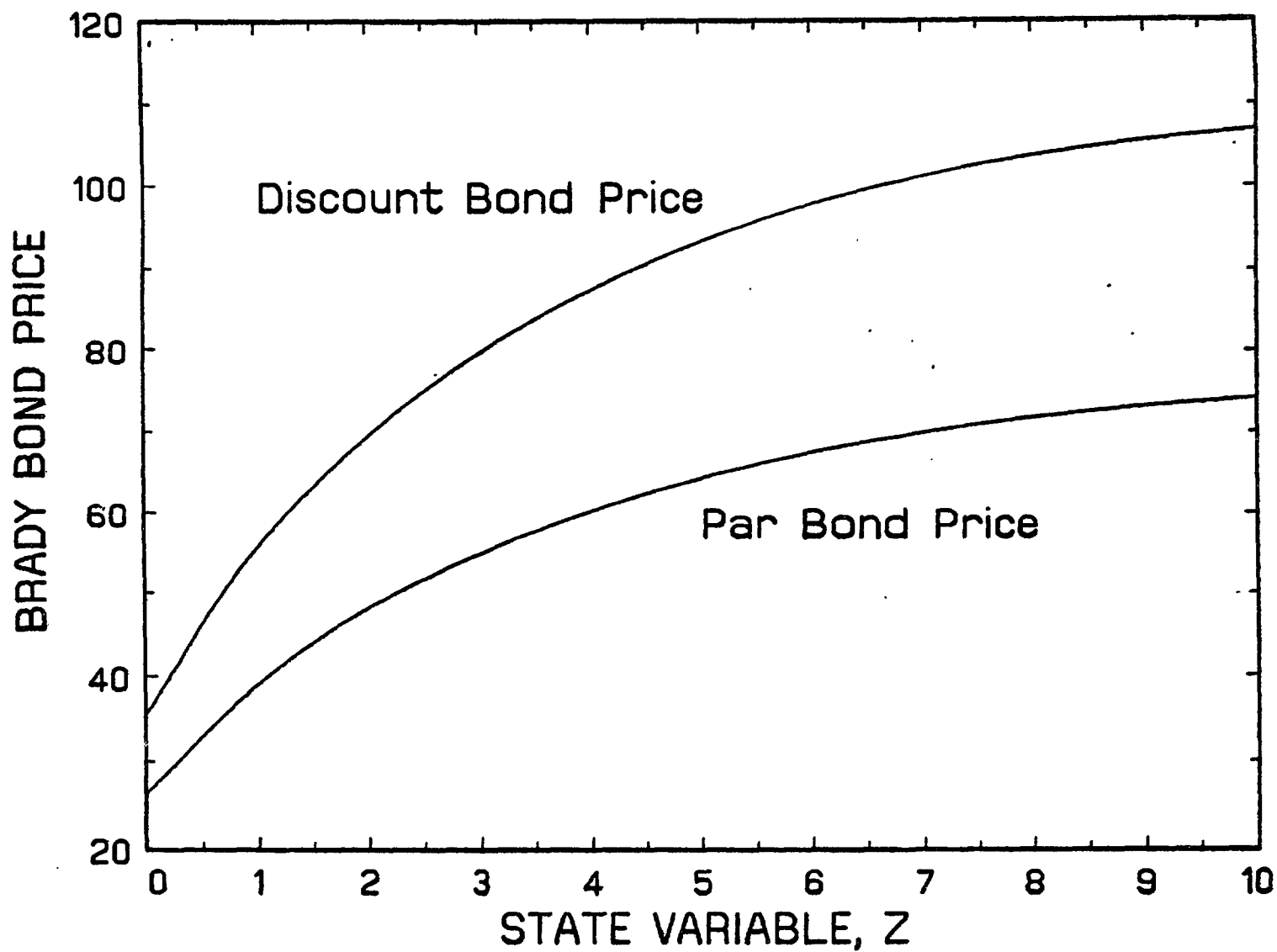


Fig 2: Mexican Brady Bond Prices

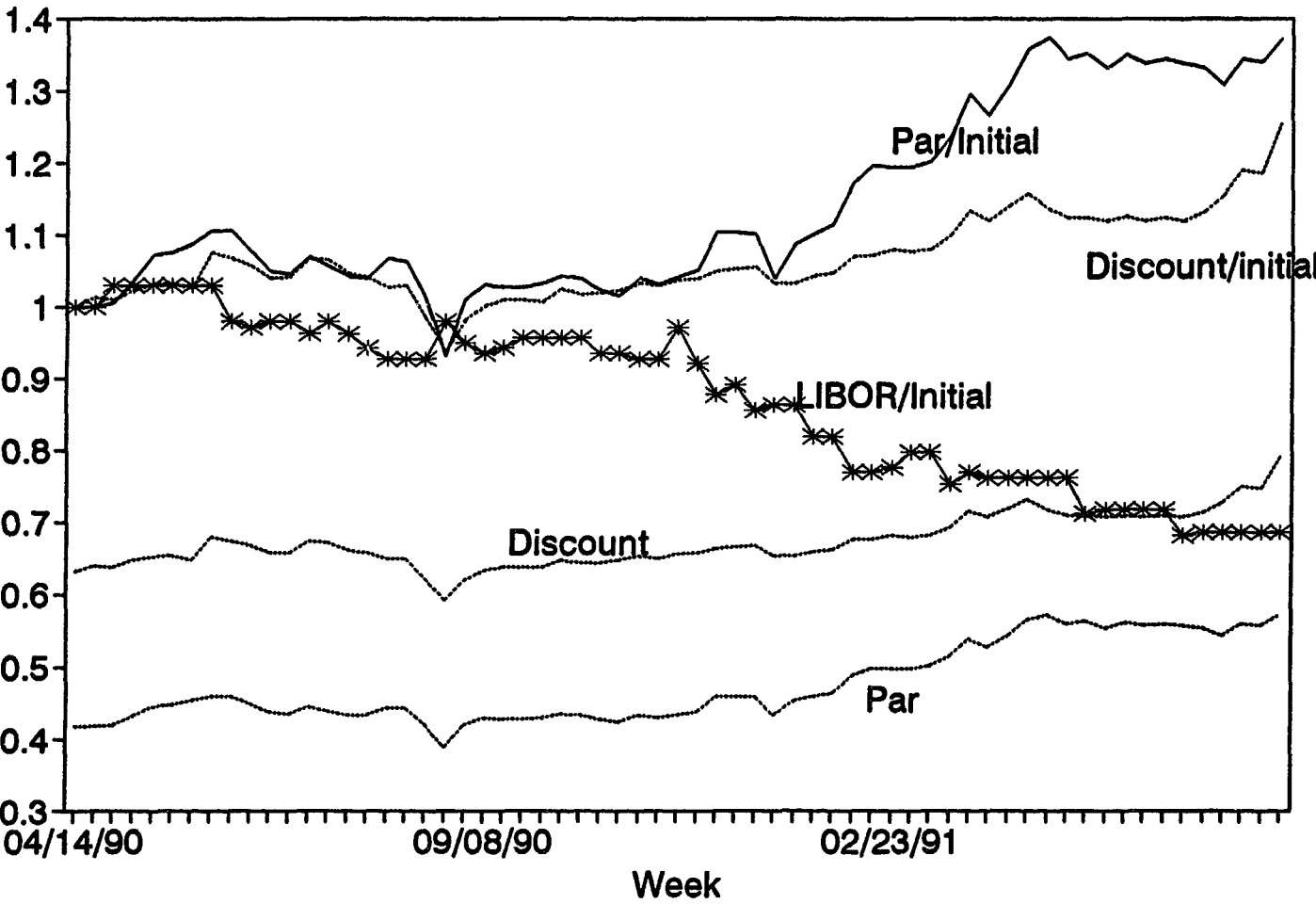


Fig 3: Venezuelan Brady Bond Prices

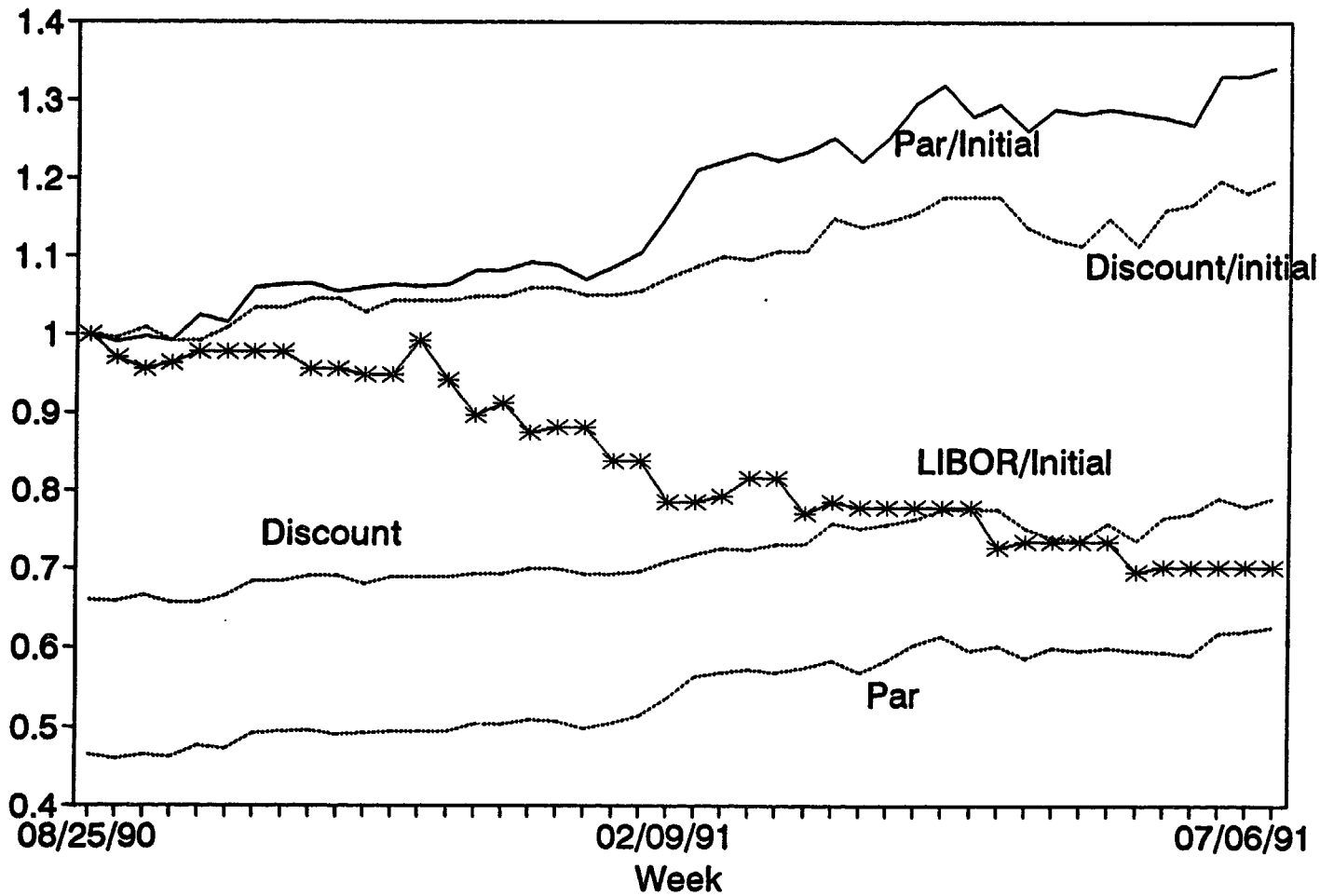


Fig 4: Mexican State Var. & Bond Prices

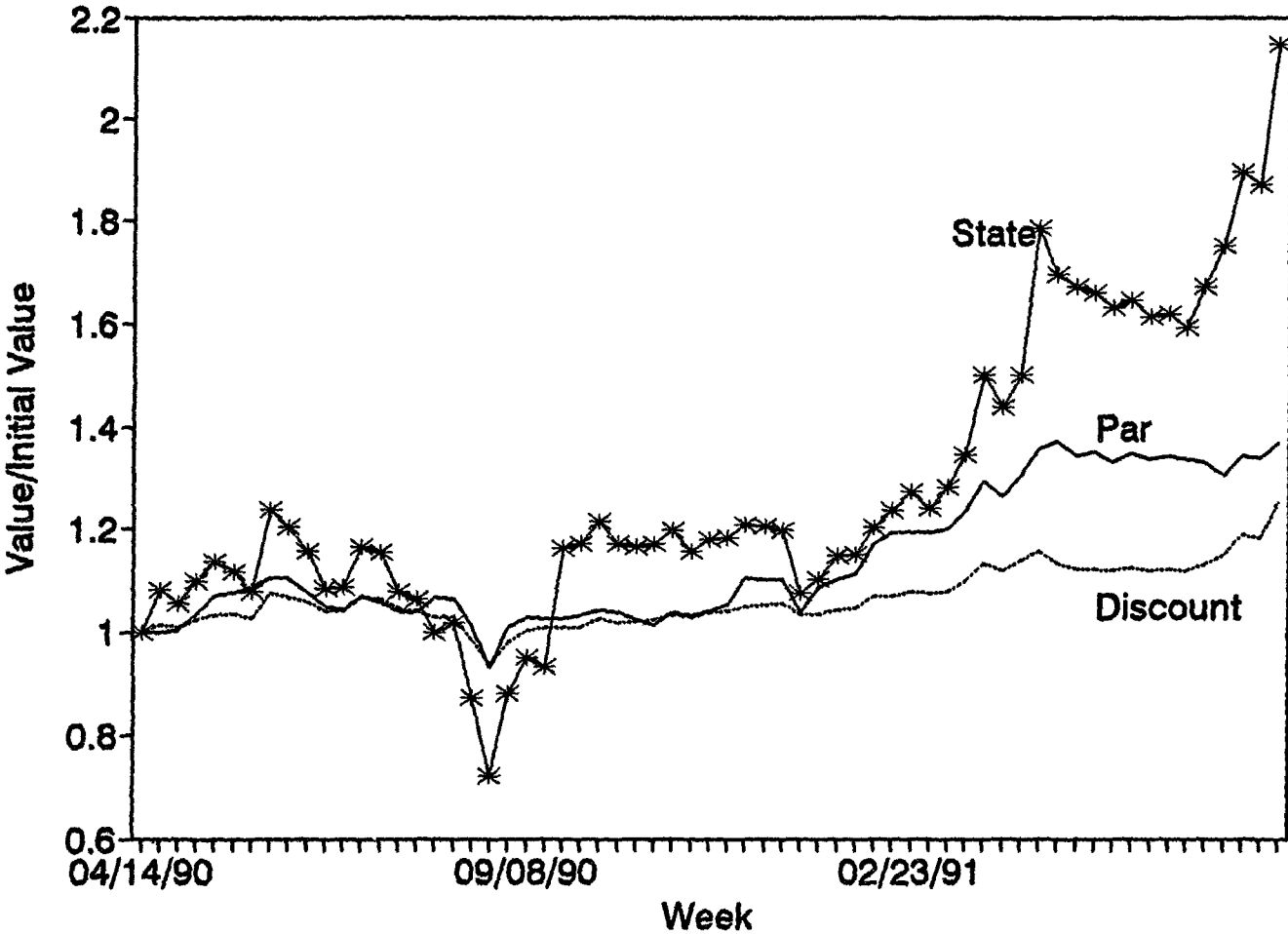
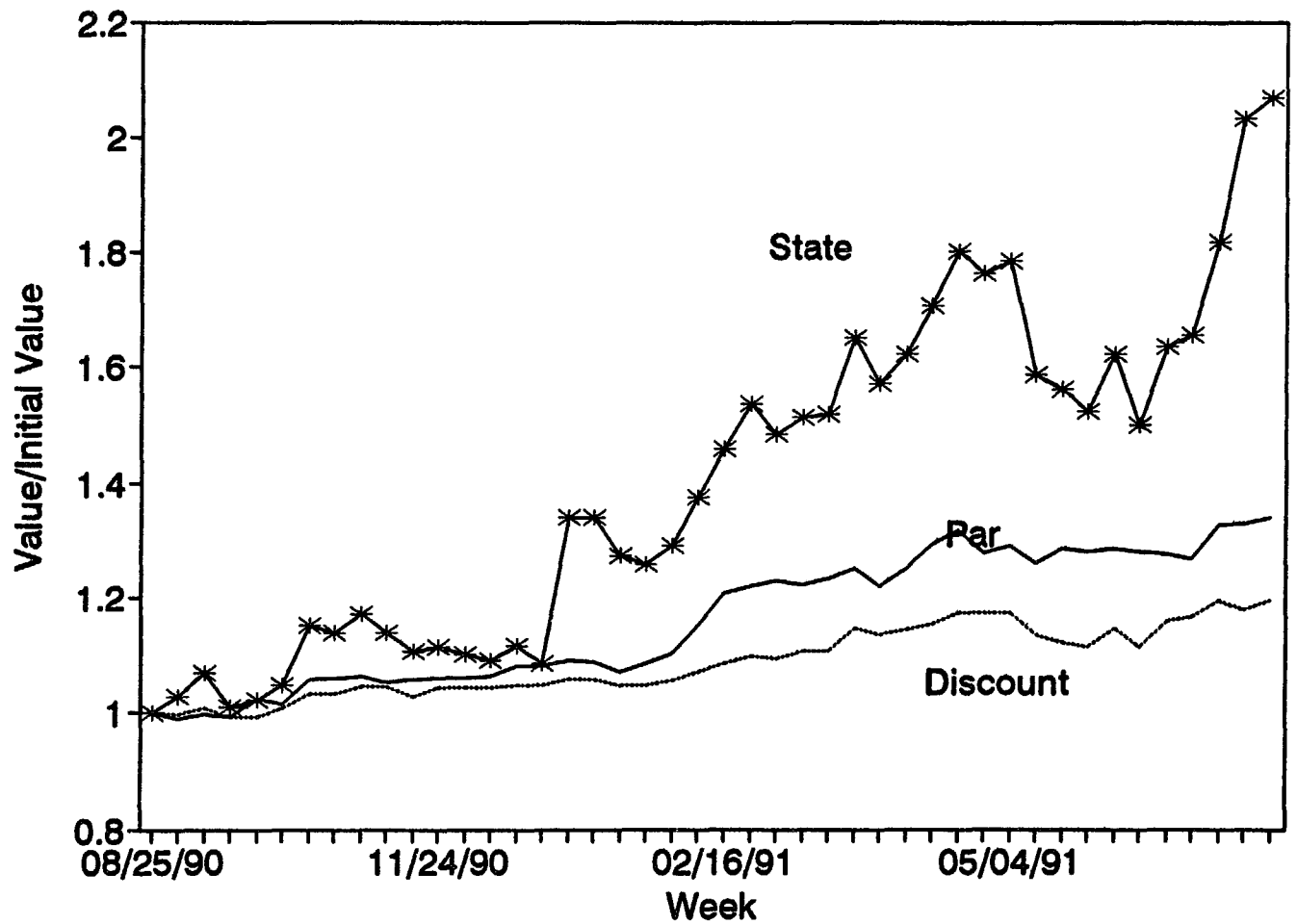


Fig 5: Venezuelan State Var.&Bond Pric.



Policy Research Working Paper Series

	Title	Author	Date	Contact for paper
WPS1019	How Effective are Directed Credit Policies in the United States? A Literature Survey	Anita M. Schwarz	November 1992	M. Raggambi 37664
WPS1020	Another Look at Population and and Global Warming	Nancy Birdsall	November 1992	S. Rothschild 37460
WPS1021	Measuring Welfare Changes from Commodity Price Stabilization in Small Open Economies	Jonathan R. Coleman Chris Jones	November 1992	D. Gustafson 33714
WPS1022	A New Approach to Evaluating Trade Policy	James E. Anderson J. Peter Neary	November 1992	M. T. Sanchez 33731
WPS1023	Tariff Index Theory	James E. Anderson	November 1992	M. T. Sanchez 33731
WPS1024	An Exact Approach for Evaluating the Benefits from Technological Change	Will Martin Julian M. Alston	November 1992	D. Gustafson 33714
WPS1025	Openness and Economic Performance in Sub-Saharan Africa: Evidence from Time-Series Cross- Country Analysis	Kazi M. Matin	November 1992	D. Ballantyne 38004
WPS1026	Financial Liberalization and Adjustment in Chile and New Zealand	Paul D. McNelis Klaus Schmidt-Hebbel	November 1992	A. Marañon 31450
WPS1027	Lessons from Bank Privatization in Mexico	Guillermo Barnes	November 1992	W. Pitayatonakarn 37664
WPS1028	Socioeconomic and Ethnic Determinants of Grade Repetition in Bolivia and Guatemala	Harry Anthony Patrinos George Psacharopoulos	November 1992	L. Longo 39244
WPS1029	Controlling Tropical Deforestation: An Analysis of Alternative Policies	Robert T. Deacon	November 1992	P. Pender 37851
WPS1030	Measuring the Effects of Urban Transportation Policies on the Environment: A Survey of Models	Alan J. Krupnick	November 1992	P. Pender 37851
WPS1031	Measuring the Possibilities of Interfuel Substitution	Robert Bacon	November 1992	P. Pender 37851
WPS1032	East Asia and Pacific Region, South Asia Region Population Projections, 1992-93 Edition	Eduard Bos My T. Vu Ann Levin	November 1992	O. Nadora 31091

Policy Research Working Paper Series

Title	Author	Date	Contact for paper
WPS1033 Latin America and the Caribbean Region (and Northern America) Population Projections, 1992-93 Edition	My T. Vu Eduard Bos Ann Levin	November 1992	O. Nadora 31091
WPS1034 Revising Financial Sector Policy in Transitional Socialist Economies: Will Universal Banks Prove Viable?	David H. Scott	November 1992	K. Waelti 37664
WPS1035 How Import Protection Affects the Philippines' Motor Vehicle Industry	Wendy E. Takacs	November 1992	D. Ballantyne 37947
WPS1036 Output Decline in Hungary and Poland in 1990-91: Structural Change and Aggregate Shocks	Simon Commander Fabrizio Coricelli	November 1992	O. del Cid 35195
WPS1037 Vocational Secondary Schooling, Occupational Choice, and Earnings in Brazil	Ana-Maria Arriagada Adrian Ziderman	November 1992	C. Cristobal 33640
WPS1038 Determinants of Expatriate Workers' Remittances in North Africa and Europe	Ibrahim A. Elbadawi Robert de Rezende Rocha	November 1992	A. Marañon 31450
WPS1039 Education, Externalities, Fertility, and Economic Growth	Martin Weale	November 1992	PHREE 33680
WPS1040 Lessons of Trade Liberalization in Latin America for Economies in Transition	Jaime de Melo Sumana Dhar	November 1992	D. Ballantyne 37947
WPS1041 Family Planning Success Stories in Bangladesh and India	Moni Nag	November 1992	O. Nadora 31091
WPS1042 Family Planning Success in Two Cities in Zaire	Jane T. Bertrand Judith E. Brown	November 1992	O. Nadora 31091
WPS1043 Deriving Developing Country Repayment Capacity from the Market Prices of Sovereign Debt	Stijn Claessens George Pennacchi	November 1992	R. Vo 33722
WPS1044 Hospital Cost Functions for Developing Countries	Adam Wagstaff Howard Barnum	November 1992	O. Nadora 31091
WPS1045 Social Gains from Female Education: A Cross-National Study	Kalanidhi Subbarao Laura Raney	November 1992	M. Abundo 36820